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DEPOSITIONAL ENVIRONMENTS AND PALEOCURRENT DIRECTIONS IN THE PRECAMBRIAN MOEDA FORMATION, MINAS GERAIS, BRAZIL

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By

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IN THE PRECAMBRIAN MOEDA FORMATION, MINAS GERAIS, BRAZIL

By David A. Lindsey
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ABSTRACT

The middle Precambrian Moeda Formation of Minas Gerais, Brazil, contains uranium and other minerals believed to be of detrital origin. Two areas of anomalously high concentrations of uranium have been discovered in conglomeratic zones that are interpreted as paleochannels. Because the distribution of uranium is believed to be controlled at least in part by sedimentation, a reconnaissance study was undertaken to assess the depositional environment and sediment dispersal pattern of the Moeda Formation.

The reconnaissance survey indicates that the Moeda Formation contains two distinct facies: alluvial and littoral (or marine). The alluvial Moeda is further divisible into at least three facies on the basis of paleocurrent patterns and minor lithological differences: one in the area of the Gandarela syncline, one in the west limb of the Moeda syncline, and a third in the area near Pitanguí. The distribution of conglomerate and the direction of crossbedding dip vectors an entrenched paleostream show that the stream flowed westward from the Gandarela syncline into the east side of the Moeda syncline. Another major stream flowed southerly along the present northwest side of the Moeda syncline. A third stream may have entered the Moeda syncline from the southwest. These streams coverged in the southern part of the Moeda syncline and

probably flowed south to the sea. The Moeda Formation in the southeastern part of the Quadrilátero Ferrífero is of littoral or marine origin. Probable Moeda Formation near Pitanguí, northwest of the Quadrilátero, was deposited by a northeasterly flowing stream.

The general model of Moeda paleogeography as inferred from the present study indicates that part of the marine facies now occupies what must have been the source of the Gandarela alluvial facies. This juxtaposition of facies may be explained by extensive lateral displacement of the marine facies in thrust sheets. Alternatively, the alluvial and marine facies of the Moeda may be of different ages.

Further sedimentological study of the Moeda Formation is recommended to better delineate known uraniferous paleochannels and to develop a more refined model of the paleogeography for use in locating new exploration targets. Additional studies of the structural geology of the area are also needed to predict the present location of paleochannels and to assess the extent to which the various facies have been transported by tectonism.

INTRODUCTION

Recent discoveries of uranium in the middle Precambrian Moeda Formation of Minas Gerais, Brazil, have opened an extensive area to prospecting. Uranium anomalies in the Moeda Formation are associated with conglomerates that contain uraninite, pyrite, gold, monazite, and perhaps other heavy minerals. These minerals are believed to be of detrital origin, although uranium may have been remobilized. Thus the uranium deposits in the Moeda Formation resemble large uranium deposits in the middle Precambrian (about 2 billion years old) sedimentary rocks of other parts of the world, notably in Ontario, Canada (Roscoe, 1969), and in the Witwatersrand of South Africa, where gold is relatively more important (Brock and Pretorius, 1964).

The probable detrital origin of the uranium in the Moeda Formation indicates that sedimentological studies should provide guides to further prospecting. To that end, I have sought to identify and map depositional environments and sediment dispersal patterns in the Moeda. This objective was accomplished by mapping as separate facies the several distinctive associations of lithologies, sedimentary structures, and paleocurrent directions. Because this study was conducted in about three weeks (May 21-June 7, 1974), it is by necessity reconnaissance in nature. Recommendations for further study are presented at the end of this report.

This study was undertaken as part of the U. S. Geological Survey's (USGS) cooperative program with the Companhia de Pesquisas Recursos Minerais, under the sponsorship of the Government of Brazil and the Agency for International Development, U. S. Department of State.

I wish to thank the staff of the Comissão Nacional de Energia Nuclear of Brazil in Belo Horizonte, under the direction of José Nilsen Villaça, for their able assistance in conducting fieldwork. Kazuo Fuzikawa and other staff geologists gave generously of their time while guiding me in the field.

GEOLOGIC SETTING

Metasedimentary rocks of middle Precambrian age crop out extensively in the Quadrilátero Ferrífero of Minas Gerais State. They lie astride the boundary between the older Precambrian terrane of the São Francisco craton to the west and the rejuvenated Precambrian metamorphic terrane to the east (Ferreira, 1972, p. 5-6). Rocks that may be of approximately the same age also extend more than 1,000 km north in the Espinaça Chain.

The stratigraphy and structure of the Quadrilátero Ferrífero has been summarized by Dorr (1969). The Precambrian stratigraphic section is divided into three series: the Rio das Velhas, the Minas, and the Itacolomí (uppermost) (table 1). Throughout most of the Quadrilátero, the Moeda Formation (quartzite, lesser conglomerate, and phyllite) is at the base of the Minas Series. It unconformably overlies rocks of the Rio das Velhas Series and is conformably overlain by the Batatal Formation (phyllite). In the east-central part of the Quadrilátero, the Moeda Formation unconformably overlies the Tamanduá Group, which there forms the base of the Minas Series.

The principal structural features that influence the distribution of the Moeda Formation are a series of synclines (the Moeda, Dom Bosco, Santa Rita, and Gandarela) that encircle the Rio das Velhas uplift

THIS REPORT						
Age	Series	Group	Formation	Lithology	Sedimentary environment	Maximum thickness, in meters (approximate)
Cretaceous(?) Tertiary(?) Recent			(Unnamed)	Canga, lacustrine and stream sand, clay, gravel, alluvium, and colluvium	Continental	100
Tertiary			Floralia	Lake and stream sediments, minor lignite	Continental	100
				Profound angular and erosional unconformity		
	Itacolomi	(undivided)		Type area: orthoquartzite, and protoquartzite, conglomerate, grit Santo Antônio facies; protoquartzite, phyllite, phyllitic quartzite, conglomerate	Paralic Molasse?	2,000? 1,000?
				Angular and profound erosional unconformity		
Precambrian	Minas	Piracicaba	Sabará	Chlorite schist and phyllite, metatuff, graywacke, tilloid, conglomerate, quartzite, minor iron-formation	Eugeosynclinal Flysch	3,000+
				Local erosional unconformity		
			Barreiro	Phyllite and graphitic phyllite	Stable shelf (blanket)	150
			Taboões	Orthoquartzite	Stable shelf (blanket)	125
			Fêcho do Funil	Quartzose phyllite, dolomitic phyllite, siliceous dolomite	Stable shelf (blanket)	410
			Cercadinho	Ferruginous quartzite, quartzite, grit, phyllite, ferruginous phyllite, minor conglomerate and dolomite	Stable shelf (blanket)	600
				Local erosional unconformity		
		Itabira	Gandarela	Dolomite and minor limestone, dolomitic itabirite, itabirite, dolomitic phyllite	Stable shelf (blanket)	600
			Cauê	Itabirite (oxide-facies iron-formation, dolomitic itabirite, minor phyllite and dolomite	Stable shelf (blanket)	350 +
		Caraça	Batatal	Phyllite, slightly graphitic phyllite, minor metachert and oxide-facies iron-formation	Stable shelf (blanket)	250
			Moeda	Paralic facies: orthoquartzite and grit, conglomerate, phyllite Blanket facies: Sericitic quartzite, quartzose phyllite, protoquartzite	Stable shelf	1,000 150
				Local erosional unconformity		
		Tamanduá	(Unnamed)	Dolomitic phyllite, dolomitic iron-formation (oxide-facies), quartzose phyllite	Stable shelf	300
			Cambotas	Orthoquartzite, conglomerate, grit, conglomeratic quartzite, minor quartzose phyllite	Paralic prismatic	1,000
				Erosional and angular unconformity		
	Rio das Velhas	Maquiné	Casa Forte	Protoquartzite, grit, conglomerate, minor phyllite and subgraywacke	Eugeosynclinal Molasse	400+
			Palmital	Phyllite, quartzose phyllite, protoquartzite, graywacke, subgraywacke, minor basal conglomerate	Eugeosynclinal Molasse	1,400
				Local erosional and possibly angular unconformity		
		Nova Lima	(Undivided)	Phyllite, largely chloritic, graywacke, carbonate-facies iron-formation, metavolcanics, minor quartzite, tilloid, conglomerate, and dolomite Rb—Sr age on muscovite 2800 million years before present	Eugeosynclinal (Flysch)	4,000+
				No basement rocks exposed in the Quadrilátero Ferrífero; all granitic rocks are intrusive		

Table 1.--Stratigraphic section in the Quadrilátero Ferrífero, Minas Gerais, Brazil (from Dorr, 1969, pl. 12)

(figure 1); a homoclinal structure bounds the northwestern margin of the Quadrilátero (not shown on fig. 1). The Moeda syncline is the least deformed area in the Quadrilátero, although the eastern limb is overturned. The southern and western limbs of the Dom Bosco and Santa Rita synclines are for the most part obliterated by extensive thrust faults (not shown on fig. 1); the Gandarela syncline is also broken by a thrust fault. The root zone of the overthrusts is to the east, and the intensity of metamorphism is also believed to increase toward the east. Rocks believed to be correlative with the Moeda Formation also crop out to the west of the Quadrilátero, near the town of Pitanguí (not located on fig. 1), in an area where the geology is not well known.

DESCRIPTION OF LITHOFACIES

The Moeda Formation is divisible into at least four facies distinguished by lithology, sedimentary structures, and paleocurrent directions. Three alluvial facies consist of conglomerate and quartzite that vary only in the details of clast composition and paleocurrent direction (fig. 2). I will refer to these facies by their locations: near Pitanguí, on the west side of Moeda syncline, and in the Gandarela syncline and vicinity. A fourth facies, believed to be of littoral or marine origin, is present in the southeastern part of the Quadrilátero (fig. 2).

Perhaps the thickest alluvial facies is present on the west limb of the Moeda syncline, where the Moeda Formation attains a thickness of more than 500 m (Wallace, 1965, p. F11). The Moeda Formation thins

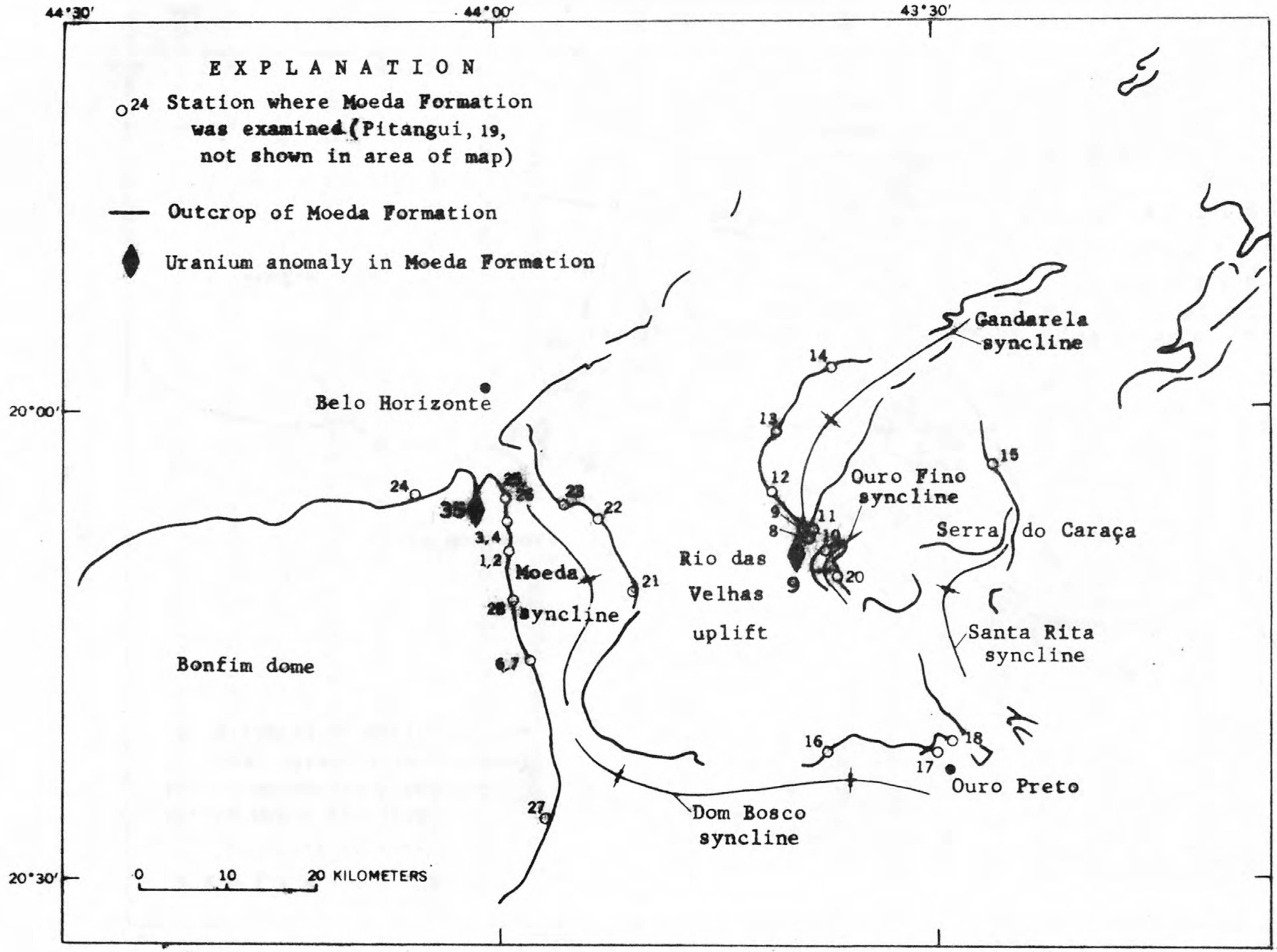

Figure 1.- Distribution of the Moeda Formation, major structural features, uranium anomalies, and localities where the Moeda Formation was examined.

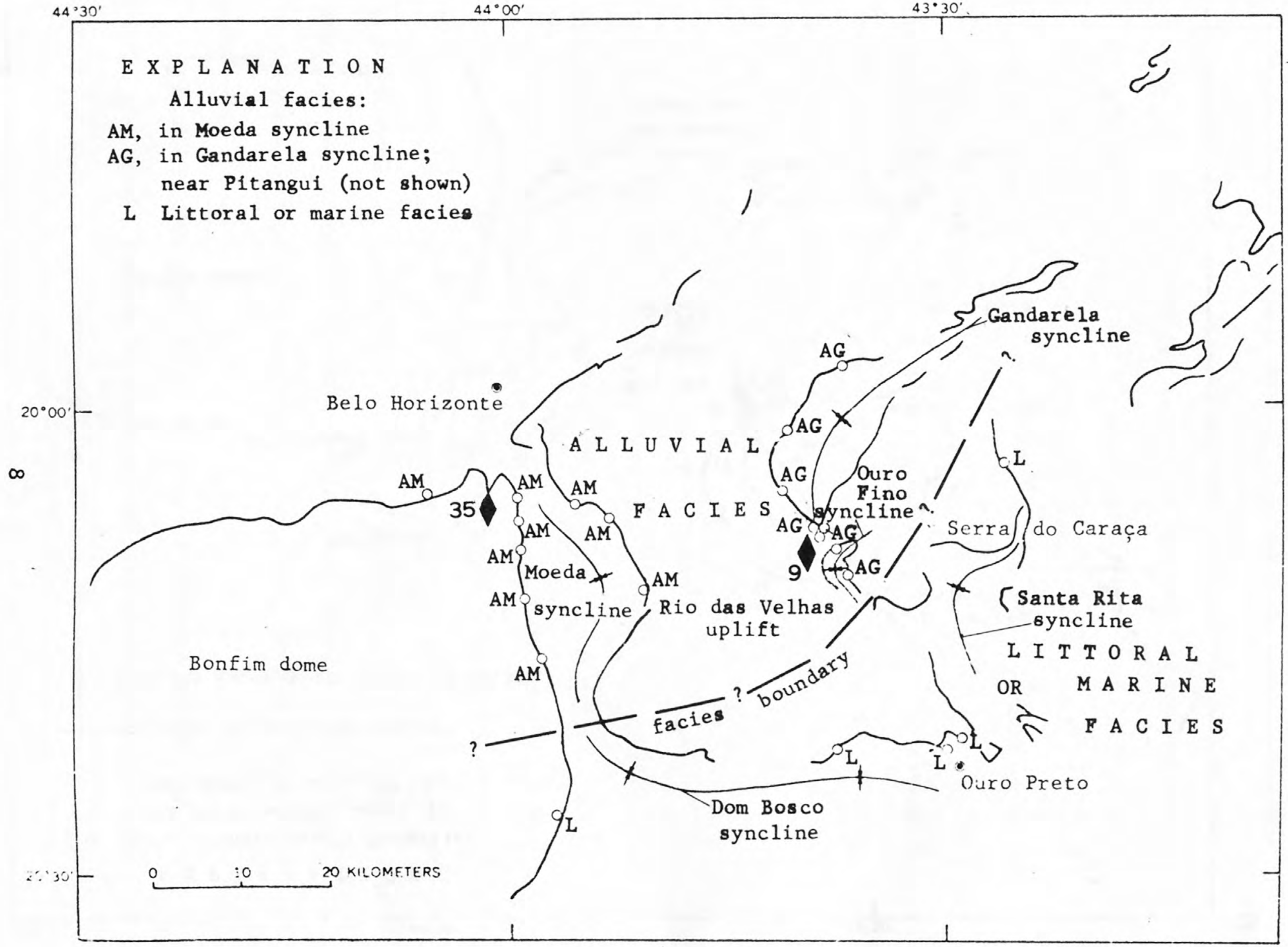

Figure 2.- Interpretation of depositional environments of the Moeda Formation

in all directions from the west limb of the syncline (Dorr, 1969, fig. 8). Throughout most of the Moeda syncline, the Moeda Formation contains three members: a lower thick quartzite, a middle phyllite, and an upper quartzite. Only the quartzite members are considered to be alluvial.

In the northwestern part of the Moeda syncline (fig. 1, Sta. 1, 2, 3, 4, 25, and 26) the lower quartzite contains abundant granule- to small-pebble sized detritus of quartzite and vein quartz; some of this conglomerate is radioactive. A few metres of coarse, poorly sorted conglomerate having a phyllitic matrix is locally present at the base of the Moeda. This conglomerate contains clasts of vein quartz and quartzite as much as 40 cm in long dimension, and abundant phyllite clasts of lesser size. It apparently represents a coarse lag gravel on the pre-Moeda erosion surface. The overlying granule- and pebble-conglomerate is interbedded with quartzite. The thickness of the beds generally does not exceed 1 m and festoon crossbedding is common.

The upper quartzite member is thinner than the lower member and contains some interbedded phyllite; quartzite beds generally do not exceed 1 m and show festoon crossbedding. A persistent conglomerate bed as much as 7 m thick is present near the base of the upper member over more than 10 km. It contains clasts of gray quartzite and white to colorless vein quartz as much as 30 cm across. Although compositionally mature, the conglomerate is poorly to moderately sorted, and rounding is also variable. The conglomerate finally disappears southward as the average maximum clast size decreases. The clasts are preferentially oriented, but this is due to stretching in the direction of tectonic lineation. The tabular geometry of the conglomerate bed indicates that the stream which deposited the alluvial facies in the area of the Moeda syncline area was not entrenched by late Moeda time, but spread its load more or less evenly over a broad surface.

Southward, at the type locality of the Moeda (fig. 1, sta. 6 and 7), conglomerate is absent and the lower member consists only of medium-bedded quartzite with festoon crossbedding. Here the top of the lower quartzite member contains only parellel laminae and is transitional into siltite and phyllite of the middle member. The phyllite of the middle member contains regular, parellel laminae only a few millimeters thick that must have been deposited below wave base, either in the sea or a large lake. No other structures were observed, even though the exposures are excellent. Similar lamination characterizes the Batatal Formation. The upper quartzite member contains numerous beds of phyllite interbedded with quartzite; festoon crossbedding is present in the quartzite beds.

The Moeda Formation in the vicinity of the Gandarela syncline attains a thickness of about 200 m (Moore, 1969, p. 115) and consists entirely of conglomerate and quartzite of alluvial origin. Coarse, thick conglomerate is confined mainly to the vicinity of anomaly 9 (fig. 2), where perhaps 100m is present. The thickness of conglomerate and size of clasts diminish abruptly to the north and south, where quartzite dominates the section. These relationships indicate that the stream deposited the conglomerate at anomaly 9 was entrenched within the alluvial plain; only sand-sized detritus was spread over the surrounding plain. The alluvial plain was extensive, but detritus did not accumulate to great thicknesses as it did in the area of the Moeda syncline.

In and around the Gandarela syncline, the conglomerate forms poorly stratified beds that generally do not exceed 1 m in thickness. Each bed consists of moderately sorted pebbles and cobbles mixed with considerable sand- and granule-sized detritus. Quartzite is nearly everywhere interbedded with the conglomerate. The clasts are angular to moderately well-rounded, and consist of black and white vein quartz and light gray quartzite. Clasts of black vein quartz as much as 30 cm long are distinctive of the conglomerates of this area. The textural immaturity of many of the clasts indicates a short transport distance ($\leq$50 km). Imbrication and crossbedding are not evident in the conglomerates; tectonic elongation of clasts is evident in some outcrops. Abundant pyrite is present in fresh exposures at various localities. The associated quartzite beds do not exceed 1 m in thickness and commonly contain festoon crossbedding. No other sedimentary structures were observed.

A third alluvial facies of conglomerate and quartzite is present near the village of Pitanguí. Here a thick section, believed to be Moeda Formation, is divisible into three members: a lower quartzite, a middle conglomerate, and an upper quartzite. The other sedimentary features of this facies are essentially similar to those of the Gandarela alluvial facies. The conglomerate beds are radioactive, but this is due mainly to monazite. Angular quartzite clasts as much as 20 cm long were observed, but most conglomerate beds consist of subround to round pebbles of light-colored quartzite and vein quartz. The upper quartzite member contains abundant festoon crossbedding. Some soft-sediment folding of crossbedded units is also present; this showed an easterly component of overfolding where the direction could be determined.

A distinctive quartzite facies of probable littoral or marine origin characterizes the Moeda Formation in the southeastern part of the Quadrilátero (fig. 2). Here, the Moeda is rarely crossbedded, and where present, the crossbeds form very low angles with the bedding. Parallel laminae are dominant and conspicuous nearly everywhere. Near Ouro Preto, this facies reaches a thickness of about 50 m, and individual beds exceed 4-5 m in thickness. The composition of the facies also indicates a marine or littoral environment. Fine, well-sorted quartz sand occurs everywhere with varying amounts of sericite. At the base of the Moeda, near station 15, several meters of conglomerate contain rounded clasts of light-gray quartzite and recrystallized quartz. The quartzite clasts are composed of fine, well-sorted quartz sand, and they resemble the older Cambotas Quartzite, which crops out extensively in the nearby Serra do Caraça. Probably both the fine quartz sand of the Moeda and the quartzite clasts contained within it were derived from the Cambotas Quartzite by wave action and longshore currents. This situation is similar to that proposed by Ketner (1968) for the source of Ordovician orthoquartzite in the western United States.

MEASUREMENT AND ANALYSIS OF CROSSBEDDING ORIENTATION

The direction of sediment transport was determined entirely from measurement of crossbedding dip azimuths. Pebble fabric is considered unreliable for paleocurrent determinations in the Moeda Formation because of the many places where tectonic elongation was observed. Care must also be taken not to confuse foliation with crossbedding; much of the Moeda displays distinct foliation that is nearly parallel to bedding. Crossbedding is best identified from laminae that exhibit compositional or grain-size variations. After the orientations of bedding and foliation are well established, crossbedding may also be identified, with care, from sets of subparallel, curvilinear fractures that develop along the lamination. At some outcrops, foliation is so pronounced that no crossbedding could be identified with confidence.

One measurement of crossbedding orientation was taken from each bed where the structure was observed. At each station, the entire available section was traversed to obtain measurements from as many different beds as possible. During field study, rotation of the crossbedding poles was done on a Schmidt net, and the resulting dip directions were averaged by simple arithmetic methods. Final rotation and statistical analysis were done by computer; the statistical parameters for each station are summarized in table 2. Computations are based on the assumption that the data may be approximated by the circular normal distribution; methods of computation are described by Curray (1956) and Pincus (1956). The average crossbedding dip direction is given by the vector mean, the strength or consistency by the vector strength in percent, and the degree of dispersion by the standard deviation. The Rayleigh test was applied to determine the probability that measurements at each station were drawn from a population of randomly oriented crossbedding sets. Only those vector means that have less than a 20 percent probability of random orientation were plotted in figure 3.

The station vector means for crossbedding (fig. 3) shows a consistent paleocurrent pattern in the vicinity of the Gandarela syncline and in the

Table 2.--Summary statistics for crossbedding directions in the Moeda Formation, Minas Gerais, Brazil.

Station number	Number of measurements	Vector mean (in degrees)	Vector strength (in percent)	Standard deviation (in degrees)	Rayleigh test for randomness probability (in percent)
1[1/]	5	346	52	90	26
2[2/]	9	187	49	87	12
3[1/]	10	104	81	39	<1
4[2/]	20	193	31	88	15
6[1/]	11	38	30	85	37
7[2/]	16	17	34	87	16
8	19	251	72	58	<1
9	11	254	60	61	2
10	14	247	40	88	11
12	28	24	28	84	11
13	13	229	82	40	<1
14	5	268	66	64	11
18	7	228	27	95	60
19[3/]	48	27	66	58	<1
20	2	224	85	--	24
21	22	260	46	74	1
22	6	161	45	83	30
23	15	286	85	34	<1
25[2/]	34	157	52	82	<1
26[2/]	27	214	73	48	<1
27	7	312	72	50	3

1/ Upper quartzite member, west limb of Moeda syncline

2/ Lower quartzite member, west limb of Moeda syncline

3/ Upper quartzite member of probable Moeda Formation near Pitanguí

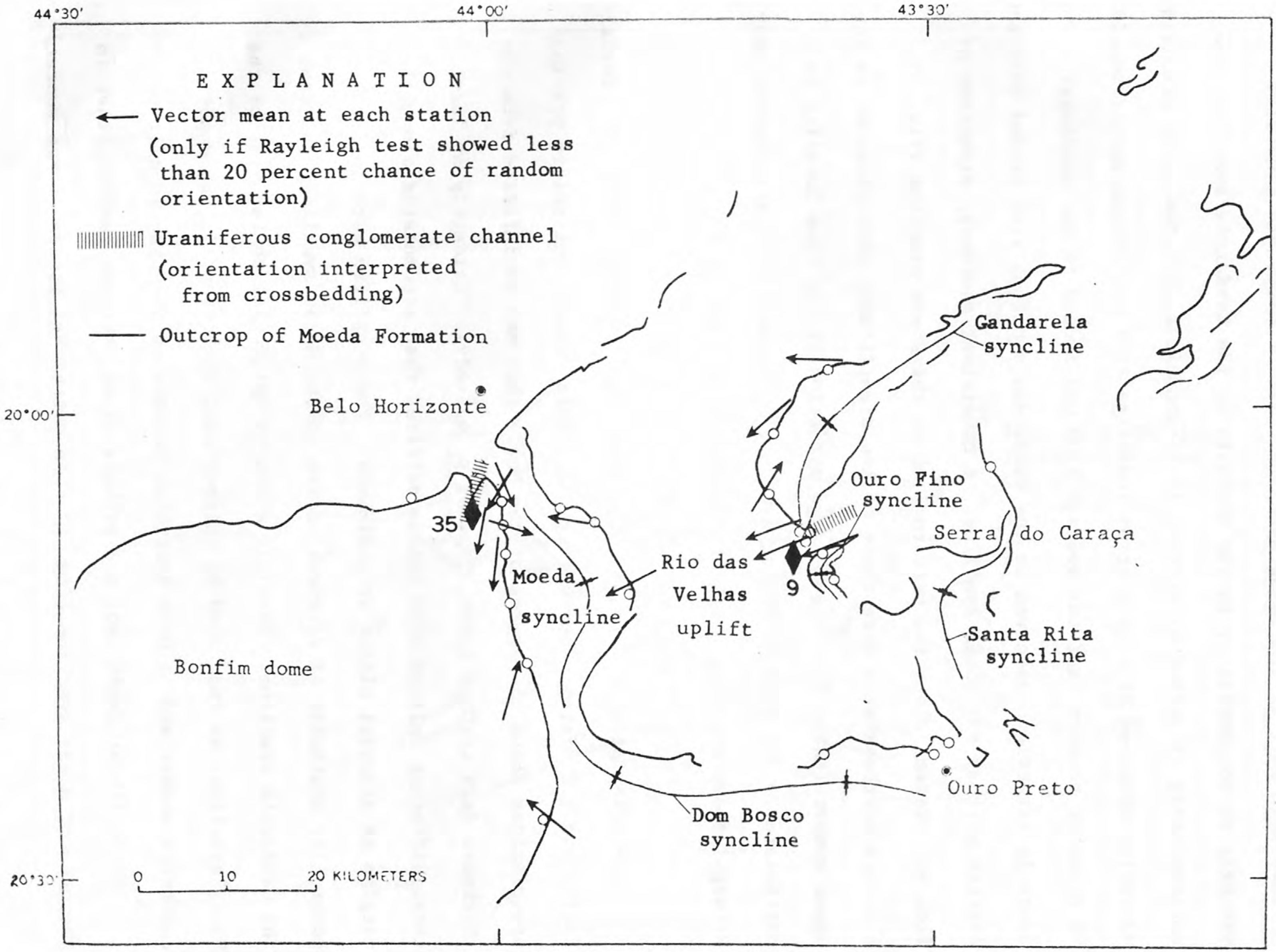

Figure 3.- Summary of crossbedding dip directions and uraniferous channels in the Moeda Formation.

northwestern part of the Moeda syncline. Vector means are generally westerly to southwesterly in the vicinity of the Gandarela syncline; the northeasterly direction at station 12 is anomalous, but the large standard deviation observed at this station indicates that more measurements should be taken to be sure that the average flow was indeed to the northeast. The westerly directions observed in the Gandarela syncline also extend into the eastern part of the Moeda syncline. A consistent southerly direction of flow was present along the western limb of the Moeda syncline (fig. 3), although northeasterly directions of low significance were observed in the upper member (table 2). The average direction at the type locality is northeasterly for both quartzite members. The upper quartzite member near Pitanguí shows a strong north-northeasterly flow direction.

RECONSTRUCTION OF MOEDA PALEOGEOGRAPHY

The orientation of crossbedding shows that each of the three alluvial facies had a different source (fig. 4). This result contradicts previous speculations about the source of the Moeda that may be inferred from the thickness data of Dorr (1969, fig. 8, p. A38-A39). Evidently at least three different uplifts shed coarse detritus that accumulated along their margins as alluvial plains or pediments. These uplifts were located, generally, southwest of Pitanguí, north of the Moeda syncline, and east of the Gandarela syncline. Possibly a fourth uplift lay to the west of the Moeda syncline, as indicated by paleocurrent directions in the upper quartzite member and in both quartzite members at the type locality.

Evidently at least two, and perhaps three, streams came together in the present Moeda syncline (fig. 4). An entrenched stream flowed westerly,

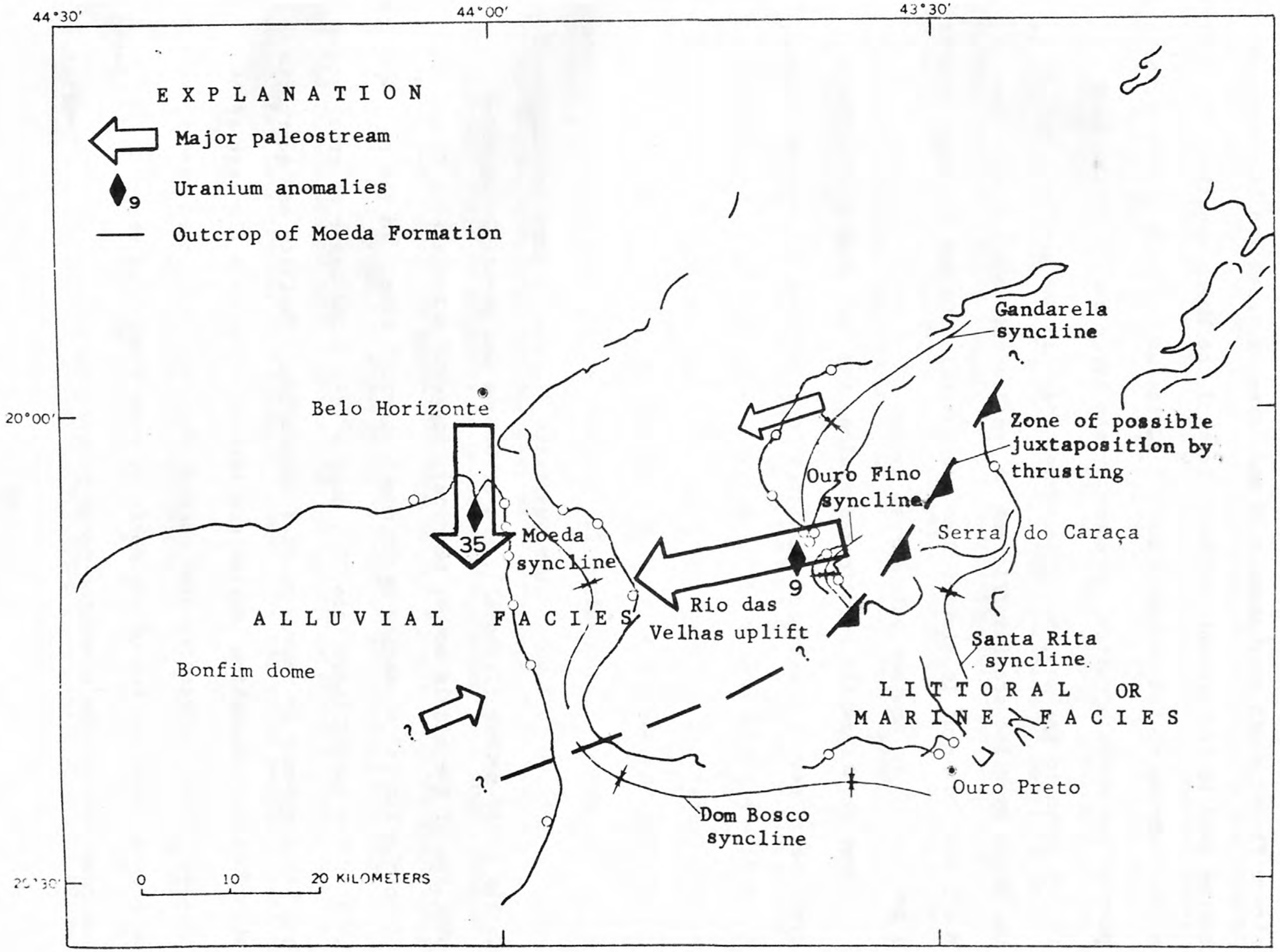

Figure 4.- Synthesis of paleocurrent directions and environmental interpretations for the Moeda Formation.

past anomaly 9, and entered the east side of the Moeda syncline. Another stream flowed south near anomaly 35 and spread a broad fan of gravel and coarse sand in the present northwest part of the Moeda syncline. Possibly a third stream flowed easterly and joined the main stream in the southern part of the Moeda syncline. Presumably the large master stream then flowed south to the sea, but paleocurrent data in the southern part of the Moeda syncline are insufficient to confirm this conclusion. The Moeda near Pitanguí is distant from the Quadrilátero and probably records a portion of yet another paleostream system.

Some stratigraphic relationships along the west side of the Moeda syncline suggest a southward transition into littoral and marine facies. The middle phyllite member of the Moeda syncline may be a tongue of the Batatal Formation, which it resembles. The southerly decrease of quartzite in the upper member along the west flank of the Moeda syncline suggests an intertonguing relationship. The sequence at the type locality of cross-bedded quartzite in lower member quartzite (fluvial), parallel-laminated quartzite in the lower member (littoral), and siltstone and parallel-laminated phyllite of the middle member (marine), suggests a transition from continental-alluvial to marine environments through time. In the southwestern part of the Quadrilátero (sta.27), only a thin (10m) layer of crossbedded quartzite appears to record fluvial deposition. Phyllite and quartzite with parallel lamination (marine and littoral) dominate the rest of the section. These inferences also suggest that a thin littoral deposit may be present near the top of the Moeda at some localities where I have assigned most of the formation to an alluvial origin.

Assignment of the Moeda in the southern part of the Quadrilátero to a littoral or marine origin is not entirely consistent with the present reconstruction of the alluvial facies. My inference that a south-flowing master stream emerged from the southern part of the Moeda syncline is consistent with a southern littoral facies. The present proximity of the littoral facies to the proposed source of the Gandarela alluvial facies, however, does not yield a consistent paleogeographic reconstruction. Assuming that the environmental assignment of each facies is correct, two explanations for the juxtaposition of the alluvial and littoral facies were considered.

The present paleogeographic reconstruction does not take into account the evident deformation and crustal shortening that occurred after deposition of the Itacolomí Series. It is possible that the present proximity of the Gandarela alluvial facies to the littoral facies is due to westward thrusting of the latter (fig. 4). Judging from the probable location of the source of the Gandarela alluvial facies, at least 30 km of east-west displacement would be required to bring the two facies into their present juxtaposition. Although cross-sections of the structure of the Quadrilátero (Dorr, 1969, pl. 1) do not show 30 km of crustal shortening, the structure of the region may be more complex than is presently thought. At present, structural data are not sufficient to assess the amount of possible east-west displacement.

If the hypothesis of crustal shortening is insufficient to explain the present disposition of the littoral facies, and if the environmental interpretations are correct, then there remains the possibility that the Moeda

Formation contains strata of more than one age. Because the overlying Batatal Formation is probably marine, the littoral facies might be reasonably correlated with the Batatal. Such a correlation would then reverse relative positions of sea and land from that which was inferred in this report. In that case, during Batatal time, the sea would have spread over the Quadrilátero from the northwest, and the shoreline (littoral facies of Moeda) would have stabilized along a continent which lay to the southeast. As discussed earlier, however, the alluvial paleocurrent patterns and stratigraphic relationships in the Moeda syncline indicate that the sea lay to the south and southeast at the end of Moeda time. Although the explanation by age difference has been seriously considered, I have concluded that the required reversal in relative positions of land and sea between Moeda (alluvial facies) and Batatal time is unlikely.

RECOMMENDATIONS FOR FURTHER STUDY

I have outlined only a broad, general model of Moeda paleogeography, based on limited data. Because the alluvial paleochannels are exploration targets for uranium deposits, it is important to recognize the limitations of the present data. It will be necessary to collect more crossbedding measurements in order to further delinate the conglomerate-bearing paleochannels; this can be best accomplished by CNEN geologists in the course of local stratigraphic and structural studies. Integration of paleocurrent data with the stratigraphic information now being collected by CNEN should provide a sound basis for prediction of conglomerate trends that have potential for uranium.

The regional model of Moeda paleogeography should also be refined and revised to aid in identifying other favorable target areas for uranium exploration. An adequate understanding of Moeda paleogeography will require 1) continuing the stratigraphic studies now being conducted by CNEN geologists; 2) additional study of sedimentary structures and measurement of directional features such as crossbedding; and 3) petrographic studies, with emphasis on comparison of the various facies. These studies might be conducted in cooperation with a specialist in sedimentology or sedimentary petrology.

Additional study of the structural geology of selected parts of the Quadrilátero would also be helpful. The question of whether large-scale lateral displacement of part of the Moeda is responsible for the present juxtaposition of alluvial and marine facies cannot be resolved without careful study of the thrust zones in the southeastern part of the Quadrilátero. Local structural studies would be useful in delineating the present location of conglomeratic paleochannels. For example, paleocurrent data at anomaly 9 show that the upstream continuation of the uraniferous paleochannel lies to the east-northeast. The channel may now be present in the overturned east limb of the Gandarela syncline or beneath the overthrust of Nova Lima phyllite. A detailed structural analysis and map of the area might locate the upstream continuation of the uraniferous conglomerates.

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